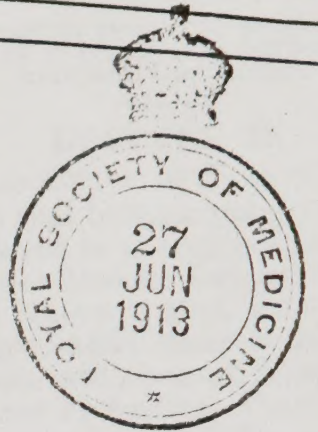


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Three years before Napoleon's death we may reasonably suppose that the inflammation of the liver which frequently appears in cases of fever endemic to tropical countries had brought about adhesions to the diaphragm and stomach. Hence it was impossible to feel any tumour in a stomach thus bound down beneath the liver. Skilled physicians like Héréau (1829)² and Boudouin (1901)¹⁰ have supposed the great ulcer found in the stomach at death to have been caused not by cancer, but by inflammation. I do not think that their opinion can be upheld; it is altogether in opposition to the appearances and characters described by Antommarchi—the only account worthy of a moment's thought. Nor do I think that the view adopted by Dr. Chaplin—that the earlier symptoms were solely due to an ulcer of the stomach—can be accepted as a full and satisfactory explanation.

It is plain, then, that Napoleon suffered originally from an endemic fever in which the liver was severely affected, and that in the course of the illness cancer of the stomach—his father's ailment—supervened, but the symptoms of the superadded disease were entirely masked by the original disease. When that interpretation is applied, Napoleon's case becomes clear, definite, and understandable. It was a condition which might well have baffled and misled the most skilful physicians in Europe, until the terminal illness in the spring of 1821, when Dr. Arnott¹¹ alleges he began to suspect that the stomach was the seat of Napoleon's trouble. The discovery of cancer at the autopsy was a revelation to all; the Emperor alone anticipated the result. Poor O'Meara, Stokoe, and Antommarchi! Dismissed, court-martialled, and maligned by the laymen in authority and by modern lay writers because they did not solve a problem which only was capable of a full solution after death. In the main they were right in their diagnosis; most unfortunate in their treatment. It is an open question whether it was the fever or the cancer which actually killed Napoleon; the best that can be said is that, whether in St. Helena or out of it, cancer would have ended the career of the great Emperor.

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THE German Gynaecological Society will hold its fifteenth annual meeting at Halle in May (14th-17th). The principal subject proposed for discussion is the relation between diseases of the heart and kidneys as well as disturbances of internal secretion with pregnancy.

THE Department of Health of the city of New York has authorized the performance by its inspectors of anti-typhoid vaccination under conditions similar to those governing the free administration of diphtheria antitoxin. The vaccine will also be supplied free to medical practitioners for their own use.

THE January issue of the journal entitled *Concrete and Constructional Engineering* contains some striking statements with reference to the safety of various buildings in London in regard to fire. Seven years ago a very large number of buildings had been officially recognized as not meeting the requirements of the London County Council in regard to general construction, the provision of escapes, and other measures designed to diminish the annual number of deaths from fire. It is stated that there are now over 90,000 buildings within the metropolitan area which are officially "unsafe." Suggestions as to how the evil might be remedied without undue delay are also put forward in the journal in question. The other articles, though mainly technical, contain nevertheless a good deal that is of general interest. A subject worthy of discussion in its pages would seem to be the truth or otherwise of a popular impression to the effect that "fireproof" buildings burn up quite as quickly, or quite as effectually so far as destruction of life is concerned, as buildings which claim no such title.

The Horace Dobell Lectures

ON

INSECT PORTERS OF BACTERIAL INFECTIONS.

DELIVERED BEFORE THE ROYAL COLLEGE OF PHYSICIANS.

By C. J. MARTIN, M.B., D.Sc., F.R.S.,

DIRECTOR OF THE LISTER INSTITUTE OF PREVENTIVE MEDICINE;
PROFESSOR OF EXPERIMENTAL PATHOLOGY IN THE
UNIVERSITY OF LONDON.

LECTURE II.

THE TRANSMISSION OF PLAGUE BY FLEAS.

MAY I remind you that bubonic plague is not an infectious disease? The patient is a negligible source of danger to his surroundings, provided he does not develop a secondary pneumonia. The reason is that, even if the excreta do contain some plague bacilli, there is no mechanism available to convey them into a second human being, as pest is not easily contracted by feeding. From an epidemiological point of view bubonic plague must be regarded as a disease of rats, in which, under suitable conditions, the infection spreads from rats to man.

It would be impossible for me to put before you this afternoon the mass of evidence for the above statements. I have already surveyed it in opening the discussion on the "Spread of Plague" at the meeting of the British Medical Association at Birmingham in 1911 (Martin, 1911), and, moreover, it is now well known.

It was difficult to explain how the bacillus was transferred to man from the rat, especially as man-to-man infection had been shown to be negligible. On epidemiological grounds, Ogata (1897), Simond (1898), and Ashburton Thompson (1900) came to the conclusion that the agent must be some form of insect, and for various reasons choice fell upon the flea.

You will naturally inquire why, if the flea is to be considered an agent of transmission from rat to man, does it not transmit from man to man? The answer is quite satisfactory, but I will, with your permission, postpone it until we have considered the case for carriage from rat to man.

If the blood of the animal contain a sufficiency of plague bacilli, some will obviously be taken in by a flea whilst feeding, and Ogata (1897) found that crushed fleas taken from a plague-infected rat produced the disease when injected into mice. This experiment was repeated with success by Simond (1898) and Tidswell (1900).

*The Mechanism by Means of which the Flea might Infect a Healthy Animal.**

The blood is sucked up from the wound made by the pricker. This structure is composed of three parts—the epipharynx and the two mandibles (Fig. 14). The apposition of the three forms a fine tube (Fig. 15), up which the blood is drawn, and passed down the gullet into the stomach by successive waves of contraction from before backwards of the muscles actuating the chitinous pharynx. The stomach is a pear-shaped organ occupying a considerable part of the abdomen of the insect. The internal economy of a flea and the arrangements of the mouth parts may be gleaned from the diagrams (Figs. 13, 14, and 15), which are borrowed from the Reports of the Commission.

The average capacity of a rat-flea's stomach was found by the Commission for the Investigation of Plague in India (Report, 1907, p. 397) to be 0.5 c.mm., and the number of bacilli in the blood of a plague-infected rat before death anything up to 100,000,000 bacilli per cubic centimetre. If, therefore, a rat-flea imbibed the blood of such a rat, it would receive into its stomach 5,000 germs.

* In dealing with the agency of fleas in the spread of plague I shall draw largely upon the work accomplished during the last few years by the Commission for the Investigation of Plague in India, with which I have had the honour to be associated. The Reports of the Commission have been published as special numbers of the *Journal of Hygiene*, 1906 to 1912.

Evidence of Multiplication of Bacilli in the Stomach of the Flea.

The Commission fed fleas on plague-infected rats until the death of the latter and afterwards on healthy animals, a fresh animal being supplied each day. Each day a number of the fleas was dissected and the stomach contents examined as to the presence or absence of plague bacilli. In 5 to 30 per cent., according to the time of year, plague germs were found up to the sixth day, and in one instance on the twentieth day (Reports, 1907, pp. 398-405). The bacilli were often present in immense numbers, far more numerous than ever seen in blood, and massed together as in culture. We have good evidence in this observation that multiplication of plague bacilli may take place in the flea's stomach. During the season of the year when the epidemic occurs the proportion of infected fleas for the first four days after removal from the plague rat was 43 per cent., on the sixth day there were 15 per cent., on the eighth day 16 per cent., and on the twelfth day 9 per cent. In the non-epidemic season only 5.2 per cent. were infected during the first six days.

The Distribution of Plague Bacilli in the Body of the Flea.

The blood on completion of the digestive process in the stomach passes into the rectum of the flea as a thick, slimy, dark-red mass, and appears at the anus as minute, dark-red or black, tarry droplets. It was demonstrated by cultural and microscopical examination that the rectal contents were often crowded with plague bacilli.

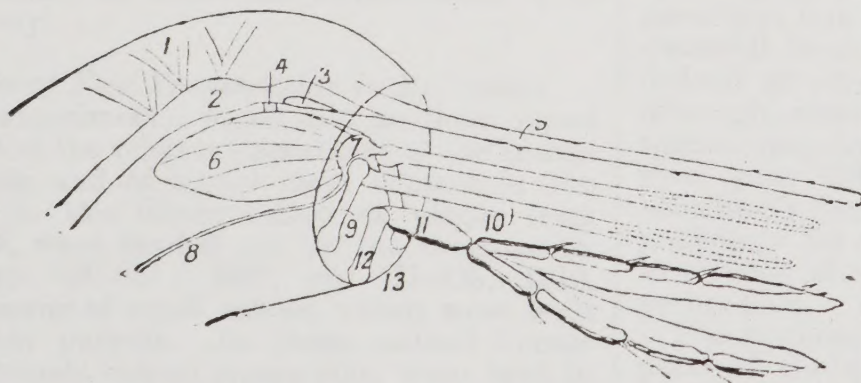


Fig. 14.—Diagram of the mouth parts of the flea. 1, Muscles operating aspiratory pharynx; 2, aspiratory pharynx; 3, mouth; 4, ligament; 5, epipharynx; 6, hypopharynx and muscles operating salivary pump; 7, salivary pump; 8, salivary duct; 9, basal element of mandible; 10, mandible; 11, labium; 12, basal element of labium; 13, perioral ring.

Fleas, taken from plague rats at intervals varying from a few hours to several days, were dissected, and the various parts of the body examined for the presence of bacilli. In not a single instance were plague bacilli observed outside the organs already mentioned. No infection of the body cavity was seen, and although particular attention was paid to the salivary glands, nothing at all resembling a plague bacillus was ever detected in them.

How the Flea may Transmit its Infection to the Healthy Animal.

Several methods of transmission are possible, such as (a) the animal eating the infected fleas; (b) the mechanical conveyance of the bacilli by the pricker; (c) the regurgitation of the stomach contents down the pricker; (d) the deposition of the faeces on the skin, the bacilli being subsequently rubbed in by scratching.

This last method is the only one which has been proved capable of bringing about infection. A well-fed flea deposits a considerable amount of faeces in a surprisingly short time, and it was proved by both the Commission for the Investigation of Plague in India (Report, 1907, p. 418) and Verbitski (1904) that wounds made by the pricker might afford a sufficient avenue for the entrance of bacilli when liquid containing them was gently applied to recent bites.

Whilst, however, experiments have shown that infection may be brought about in this way, the possibility of infection by a regurgitation from

the stomach preliminary to sucking blood cannot be excluded.

Proof that Plague is Carried from Animal to Animal by Fleas.

Simond (1893) infected one rat from another by placing them in a bottle together with twenty fleas. The second, uninfected rat, was enclosed in an iron box with a grating, so that the two animals could not come into contact. Gauthier and Raynaud (1902, 1903) repeated Simond's experiments under better controlled experimental conditions. They employed a cage divided in the middle by two wire grills 2 cm. apart, placed in a glass jar. In one compartment was placed an inoculated white rat on which had been deposited a dozen fleas captured upon rats from ships in the harbour at Marseilles. When the inoculated animal died a healthy rat was placed in the second compartment, and after some hours had elapsed, during which the fleas transferred themselves from the dead to the living animal, the cadaver was removed. Gauthier and Raynaud succeeded five times in conveying the infection from one rat to another; the number of negative experiments is not stated. An examination of the stomachs of the fleas found upon the septicæmic animals showed the presence of *B. pestis*. The fleas used in their early experiments were not identified. Tidswell (1903) made further attempts to convey plague from rat to rat by the agency of fleas, but was unable to do this.

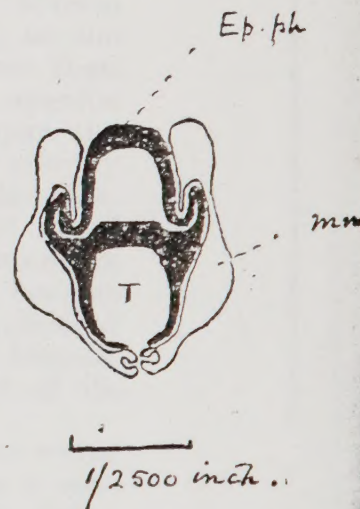


Fig. 15.—Transverse section of piercing organ of flea. Ep.ph., Epipharynx. Mn., Mandibles. T, Tube through which blood is sucked.

Verbitski (1904) carried out an extensive series of experiments on the flea-transmission of plague in St. Petersburg. He showed that the plague bacilli could be recovered from the stomach contents of fleas six days after they had fed on plague rats, and that the faeces of such fleas contained the *B. pestis* for about the same time. He succeeded in infecting rats with fleas from diseased rats fifteen times in seventy-six experiments. In each experiment ten possibly infected fleas were allowed to feed on the rat. Verbitski also made experiments similar to those of Gauthier and Raybaud described above, and out of forty experiments, using ten fleas apiece, infection was conveyed in four.

Liston (1905) pointed out that the common flea infesting rats in India was not *Ceratophyllus fasciatus* or *Typhlopsylla muscui*, as in Europe, but a non-pectinated flea identified by Rothschild as *Xenopsylla cheopis*. Liston observed multiplication of the plague bacillus in the stomach of this flea. Although his experiments on transmission, which were made by allowing fleas to bite first an animal suffering from plague and subsequently a healthy animal, were not successful, he brought forward much interesting and valuable circumstantial evidence in favour of the view that plague is epidemiologically thus spread. He showed that *X. cheopis* takes readily to another host, for example, guinea-pigs and man, when rats are not available.

The possibility of the rat-flea carrying plague from one rat to another was demonstrated in a considerable series of experiments by the Commission for Investigation of Plague in India (Report, 1906, pp. 435-450). A glass case was used containing two wire cages side by side, each standing in a tin tray which collected the urine. Both trays were filled with sand in order to provide dryness and shelter for the fleas. Each cage was furnished with a lid through which the rats were introduced and food and water given to them, and the whole apparatus was covered in with fine muslin to prevent the escape of the fleas. A rat placed in one of these wire cages could not come in contact with a rat in the other cage, nor with its urine or faeces.

The method of experiment was as follows: A plague-infected rat and a number of rat-fleas were placed in one of the wire cages. After the rat died, a fresh healthy rat was put into the other cage, the corpse of the infected rat being left in for twenty-four hours longer.

Sixty-six experiments with English white rats and with Bombay wild rats were done in this way, with the result that 30 healthy rats contracted plague; fleas formed the only apparent means of transmission of the bacilli from rat to rat.

In order to exclude aerial infection a second series of experiments was carried out, in which fleas were taken from a rat which had died of plague and placed on a fresh rat in a clean flea-proof cage of similar construction to that already described, but containing only one wire cage. Out of 38 experiments 21 successful transmissions were obtained in this way.

The Importance of Flea-Transmission in Epizootics.

The following experiments, which had as their object the determination of the relative importance of the Indian rat-flea, *X. cheopis*, and of actual close contact in the absence of fleas in the dissemination of plague from animal to animal, were carried out by the Commission (Reports, 1906, pp. 450-467; 1907, pp. 421-436; 1910, pp. 315-335) in a series of small cabins, which were built especially for this purpose. In these animal houses plague-infected animals, rats or guinea-pigs, were kept in close contact with healthy animals. They ran about together in a confined space and ate out of the same dishes.

The plague-infected animals were allowed to die, and the corpses were not removed until some time after death. In some instances the concentration of infection was very great, in one case 21 infected animals being at one time in contact with 25 healthy ones. The cabins were never cleaned out, so that the animals ate food contaminated with the faeces and urine of their infected companions. In the experiments with rats, the healthy frequently ate the carcasses of the infected ones introduced.

Sixty-six series of experiments were carried out, each involving about 40 to 70 animals. In 35 experiments fleas were present, and 31 were control experiments in which no fleas were introduced. In all the control experiments

not one of the healthy animals contracted plague, whereas in those cases where fleas were present an epizootic occurred, varying in extent and rate of spread according to the number of fleas present.

Some interesting experiments (Reports, 1906, p. 461) were also carried out in the animal houses that had been used for some of the previous experiments. Guinea-pigs and monkeys were introduced into them for one night. Some of the animals were in cages placed on the floor, and others in cages covered by fine muslin, gauze, or surrounded by a layer of sticky fly-paper, 6 in. wide—that is, the simplest precautions were taken to exclude fleas.

Of 13 unprotected monkeys, 6 died; of protected, none. Of 24 unprotected guinea-pigs, 18 died; of protected, none. The animal houses remained infective three weeks after the last animal had died of plague. This period corresponds with the maximum time fleas fed on a plague rat have been shown to remain infective when placed on a series of healthy animals.

Experiments in Plague Houses.

The Commission subsequently (Reports, 1906, pp. 467-482, and 1907, pp. 436-446) repeated similar experiments in plague houses in Bombay. The infectivity of 142 houses where cases had occurred or rats had died was tested by placing a guinea-pig there overnight. The guinea-pig was subsequently segregated, and in 31 cases it died of plague.

Ninety-two experiments were made in which two similar animals—monkeys, guinea-pigs, or rats, the one protected by gauze or sticky paper, the other not protected—were placed in suspected houses; 15 unprotected animals died; none of the protected.

On ninety-six occasions fleas taken off guinea-pigs which had spent the night in a suspected house were transferred to a healthy animal. In 26 cases the second animal died of plague, although not infrequently the guinea-pig from which they had been removed escaped infection. The conclusion that in a plague-infected house the infection is due to infected rat-fleas, and not to an infection of the soil or the air, seems to me abundantly justified.

Fleas as the Agents of Transmission from Rat to Man.

In considering how far the results just detailed can be applied to man, we enter at once upon less secure territory, because it is impossible to put conclusions to the test of experiment. The only measure of the correctness of such an interpretation is its adequacy to interpret all the known epidemiological facts concerning the spread of plague.

The justice of applying the results of these animal experiments has been severely criticized in several quarters, and particularly by Galli-Valerio (1907), on the ground that rat-fleas do not bite man. It is true that, speaking generally, different animals harbour specific parasites; but the more we learn upon this subject the clearer it becomes that such specificity is not so sharply defined as was imagined, and that a particular flea, although commonly confined to a few hosts of allied species, may frequently be found in considerable numbers upon quite different animals. Moreover, it has become abundantly clear that a flea, although exhibiting a decided preference for one species, will, if hungry, betake himself to animals of widely different type in the absence of its proper host.

The common flea found on rats in India and other warm parts of the world* is *X. cheopis*. This flea is a non-combed species, and not unlike the human flea, *Pulex irritans*, in appearance. That *X. cheopis* readily feeds on man was observed by Tidswell (1903), Gauthier and Raybaud (1903), and Liston (1905). The Commission for the Investigation of Plague in India kept *X. cheopis* alive for four weeks upon an exclusively human diet, and my colleague Mr. Bacot has bred them for years on the same regimen.

With regard to the readiness with which *Ceratophyllus fasciatus*, the common rat-flea in Europe, attacks man, considerable divergence of opinion has hitherto existed. According to Wagner (quoted by Tiraboschi, 1904, p. 180), Tiraboschi (1904, p. 266), and Galli-Valerio (1907), this

* The distribution of rat-fleas has recently been dealt with by Dr. Chick and myself in the *Journal of Hygiene*, vol. ii, p. 129 (1911).

Table showing Results of Feeding Experiments with *Ceratophyllus fasciatus*.

	Subject.								Summary.	Rat.	Rabbit.
	C. J. M.	H. C.	A. M.	J. H. S.	H. Y.	G. F. P.	H. W. A.	S. R.			
Total number of experiments ...	161	118	39	33	52	51	40	23	517	101	32
Positive	106	65	30	12	36	25	19	15	308	59	23
Negative	55	53	9	21	16	26	21	8	209	42	9
Per cent. positive	65.8	55.1	76.9	36.4	69.2	49.0	47.5	65.2	59.6	58.4	71.9

flea does not bite man. On the other hand, Gauthier and Raybaud (1903 and 1909) and McCoy and Mitzmain (1909) found that when hungry it fed on man with readiness.

Dr. Harriette Chick and I (1911) have made some hundreds of experiments on this question, and are at a loss to understand the negative conclusions arrived at by Tiraboschi and Galli-Valerio. Under the conditions of our experiments *Ceratophyllus fasciatus* fed upon man as readily as upon a rat. Nevertheless, it is doubtful whether *Ceratophyllus fasciatus* is attracted to man as readily as is *X. cheopis*. Compared with the latter, it is a poor jumper.

We also made 107 experiments with *Ctenophthalmus agyrtes*, a flea common on *Mus decumanus* in this country, when living in fields, ricks, or barns, and 122 experiments with the mouse-flea, *Ctenopsylla musculi*. Under the conditions of the experiment the former would not bite man at all, and the latter only very occasionally. This latter experiment is interesting, because mice, although dying of plague, have not been found to be associated in the same way as rats with the origin of plague epidemics.

The Capability of Flea Transmission to Interpret the Epidemiological Facts regarding Bubonic Plague.

(1) Poverty, dirt, storage of grain in the bedroom, accumulation of refuse, and insanitary conditions generally, have been shown to be effective in so far as they lead to the support of a large rat population in close association with human beings. All these conditions also increase the population of rat-fleas, and man's accessibility to them.

(2) In 75 per cent. of cases the situation of the bubo is such that the bacillus must have obtained entry at some superficial area of the body. This is also consistent with infection by fleas

(3) A number of instances have occurred during the last ten years in India in which the introduction into a distant village of the effects of a person dead of plague has been followed after an interval of about a week by mortality amongst the rats, and subsequently by an epidemic of plague. The same sequence has also taken place after the visit of an individual who had worked or resided in a house where some of the inmates had suffered from plague, although the stranger himself did not suffer from the disease.

These observations are better explained on the assumption that the infection was transported in the bodies of fleas contained in the clothing or upon the person of the stranger than by any other suggestion that has been put forward, for at the earliest opportunity rat-fleas would betake themselves to the rats, and could thereby start an epizootic. That such transmission of rat-fleas does actually happen has been proved by the Commission for the Investigation of Plague in India, members of which frequently carried away rat-fleas upon their persons and clothing when visiting native quarters in the course of their scientific duties.

(4) Perhaps the most striking feature of epidemics of bubonic plague is the marked seasonal prevalence of the disease amongst rats and amongst men. In places where it is endemic the epizootic, followed by the epidemic, starts at or about the same time each year, grows, declines, and more or less disappears. As one passes away from the Equator the plague season becomes later. In Bombay the height of the epidemic is in March, in Lahore in April, in Jhelum in May, in Rawal Pindi in June, and further north in July, August, and September. The epidemics of London in 1665, and of Marseilles in 1720, reached their maximum in September. The effect of latitude in determining the season when plague flourishes is analogous to that upon the flowering and seeding of a

plant, and indicates dependence upon some biological factor. Within the tropics, where temperature variation is less and the seasons are determined by the prevailing winds and rainfall, the epidemic season is also well defined, but varies in different localities.

The seasonal incidence of plague is not due to any periodicity in the breeding of rats. In India, in localities where the latter was investigated, it bore no relation to the season when plague occurred. It was found by the Commission (Reports 1908, p. 266; and 1910, pp. 446 and 483), however, that the epidemic season coincided with the

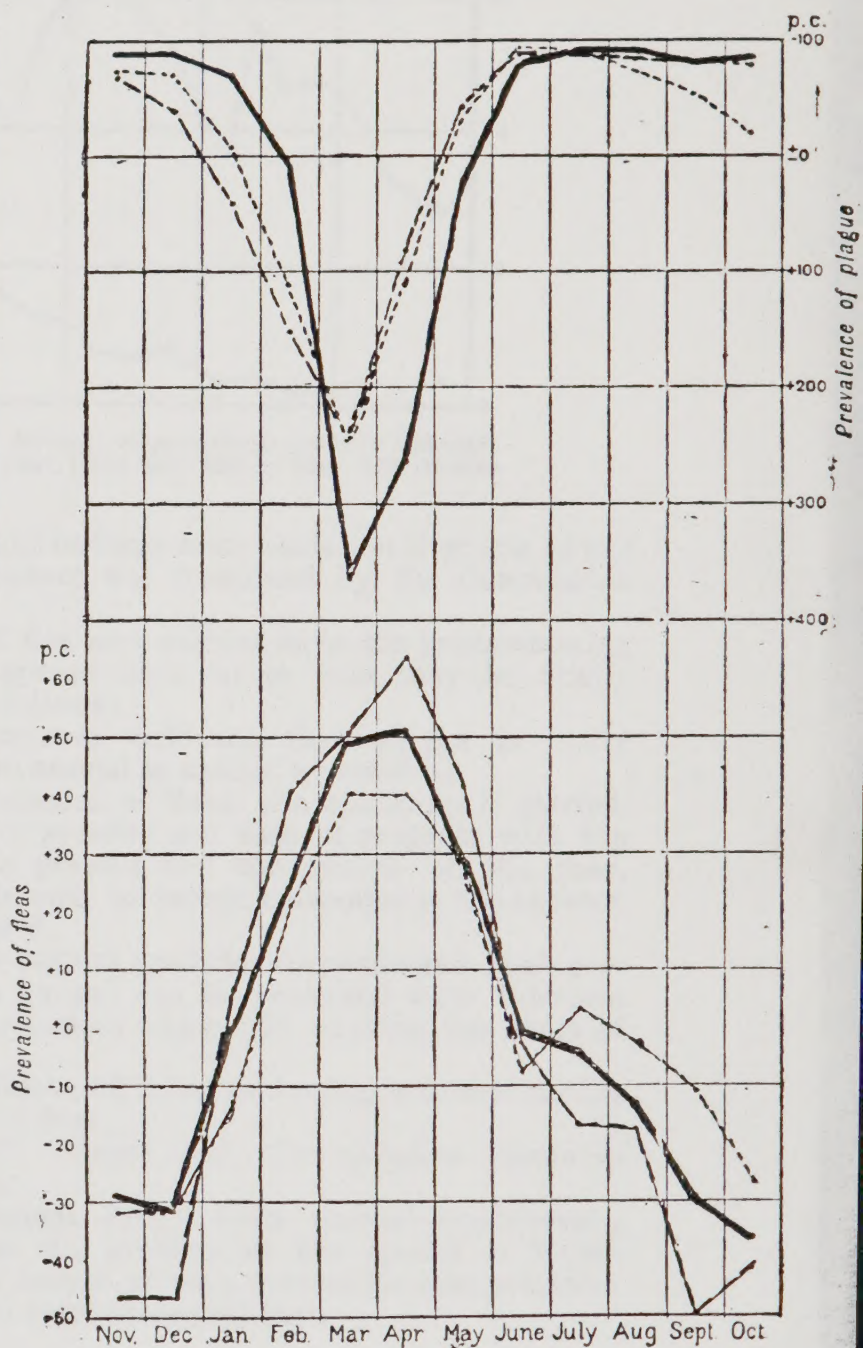


Fig. 16.—Prevalence of fleas in Bombay

Human plague. Fleas on all rats.
Plague in *M. decumanus*. Fleas on *M. decumanus*.
Plague in *M. rattus*. Fleas on *M. rattus*.

period of greatest flea prevalence. In Bombay, Belgaum, Poona, and two Punjab villages the Commission undertook a census of rat-fleas upon captured rats, in the course of which the fleas on 150,000 rats were recorded. In each case the observations extended over more than one year.

The analysis of the figures showed a seasonal variation in the number of rat-fleas in all the localities. The average number per rat varied in Bombay between 3 and 7, in Poona between 2 and 11, in the Punjab between 2 and 12, and in Belgaum between 1 and 17. The interesting point is that

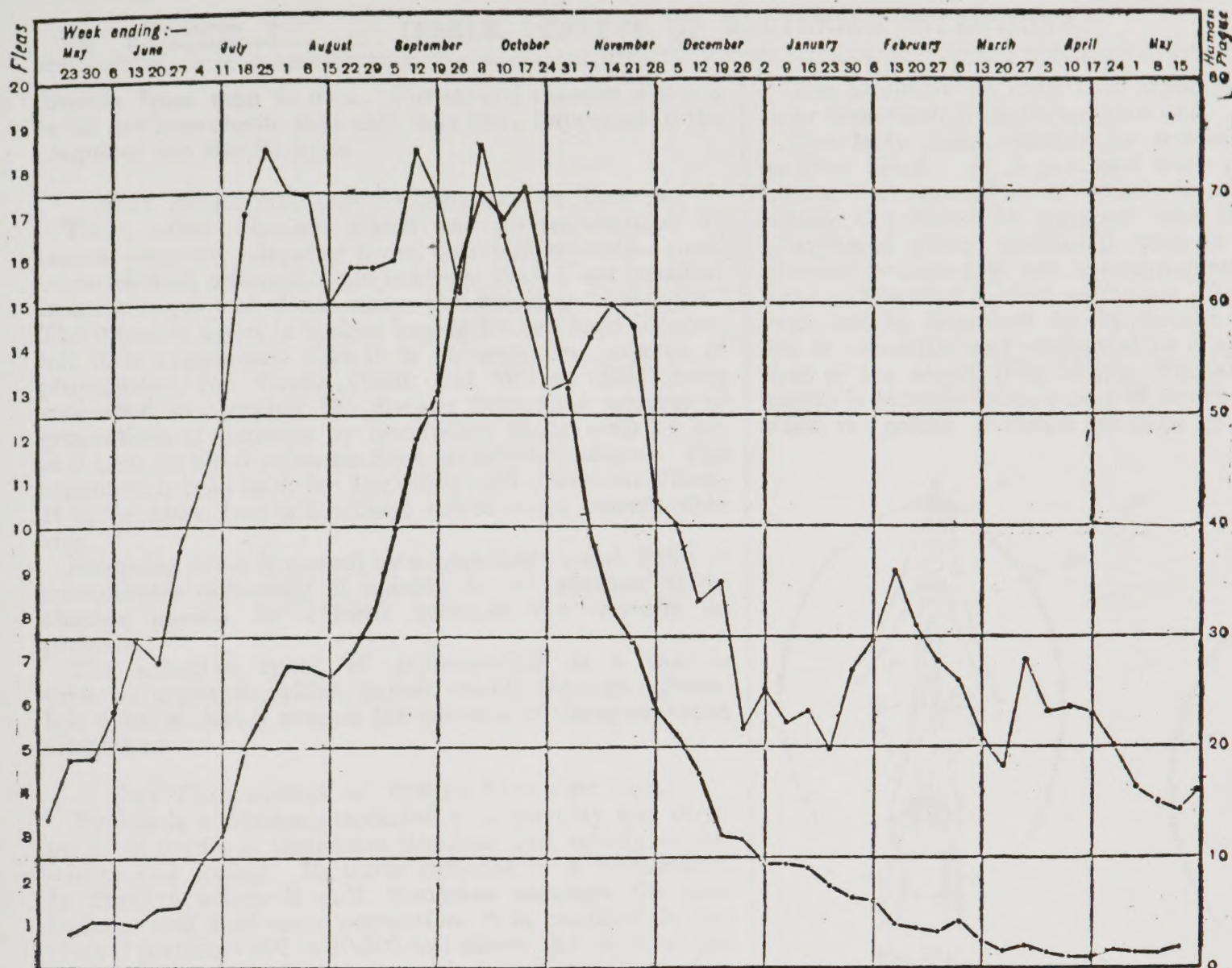


Fig. 17.—BELGAUM. ——— Average number of fleas per *Mus rattus*: weekly figures: observations made in 1908-1909.
 ——— Average number of deaths from plague, calculated for each week of the year, from May, 1897, to May, 1909 (twelve years), in Belgaum city.

in all the places examined plague is epidemic when the average number of fleas is well above the mean, and the height of the epidemic corresponds fairly closely with the season of maximal flea prevalence. This coincidence is brought out in the attached charts (Figs. 16 and 17) borrowed from the reports, which show the variations in the number of fleas per rat and number of deaths from plague each week for Bombay and Belgaum respectively.

A similar seasonal variation in the prevalence of *X. cheopis* and correspondence between the maximum of these fleas and the epidemic period has been observed by Kitasato (1909) in Japan, Tidswell (1910) in Sydney, and by Gauthier and Raybaud (1910-11) at Marseilles, and by Andrew (1911) in Tongschang in Northern China. The incidence of the epidemic period in the season of greatest flea prevalence under such different climatic conditions as obtain in Bombay, the Punjab, Poona, Tongschang, and Marseilles, is in itself suggestive, and, in view of the results of animal experiments already referred to, one is justified in believing that the most favourable time for the epidemic is largely determined by the seasonal prevalence of rat-fleas.

(5) The rat-flea hypothesis also affords an interpretation of the fact that epidemics decline when the mean daily temperature passes 85° F. A mean temperature of 85° F. in India means also dry weather. Fleas, whether in the larval, pupal, or imago state, are rapidly killed off at this temperature unless associated with a high degree of humidity.

The Commission for the Investigation of Plague in India found that in Bombay the proportion of fleas which became infected, the time they remained infected, and the number of successful experiments on flea transmission was greatest during the winter months (Reports, 1907, pp. 197-204; 1908, pp. 510-515 and 529-538). An analysis of their results showed 67 per cent. successful transmissions when the temperature was 73° to 78° F., against 14 per cent. successes when the temperature was 82° to 85° F. Transmission experiments were therefore carried out simultaneously at 70° and 85° F. in suitable chambers both upon rats and guinea-pigs. The results were consistent with previous experience. The possibility that the virulence of

the bacillus might undergo some variation if grown at one or other temperature was examined by the Commission and excluded.

The claims of flea transmission to be the predominating mechanism of spread from rat to man may be briefly summarized as follows:

1. The experimental evidence that plague is easily transmitted from animal to animal by rat-fleas.

2. That in presence of fleas, the epizootic, if started, varies as regards severity and rate of progress with the number of fleas present and the season of the year, whereas all attempts to induce epizootics in the absence of fleas have failed.

3. That under natural conditions (experiments in plague-houses, etc.) an animal can be protected from infection by any simple procedure which will exclude the visits of fleas.

4. The only discovered infection in plague-houses resides in plague-infected fleas.

5. Rat-fleas *X. cheopis* and *Ceratophyllus fasciatus* readily bite man.

6. The conclusions drawn from animal experiments, when applied to the problem of the spread of plague amongst human beings, afford a reasonable interpretation of every cardinal epidemiological fact.

The Part taken by the Human Flea.

It is possible to transmit plague experimentally by means of *P. irritans*. Nevertheless the direct transmission of the disease from man to man cannot, at the present time, be of frequent occurrence, or we should have evidence of direct infection instead of dependence upon the epizootic.

The reason why the human flea is ineffective is because in human cases the average degree of septicaemia before death is so much less than in rats that the chance of a flea imbibing even a single bacillus is small.

A variation of the plague bacillus in the direction of greater infectivity, with perhaps diminished toxicity leading to a higher degree of septicaemia in man, would permit of direct transmission by human fleas. Bubonic plague would then be independent of the rat, and spread

directly from man to man. For several reasons it seems to me not improbable that this may have happened in the plague of the Middle Ages.

SOME OTHER DISEASES TRANSMITTED BY INSECTS.

Three other diseases which can be transmitted by insects—typhus, relapsing fever, and poliomyelitis—must be mentioned, although I am not sure that I am justified in including any of them under the heading "bacterial." The infective agent in typhus has, so far, not been isolated, but it is ascertained that it is an organism capable of propagation, for Nicolle (1910) and Wilder (1911) have succeeded in carrying the disease through a number of generations of monkeys by inoculating them with 1 c.cm. to 5 c.cm. of blood or serum from an infected animal. The organism is held back by Berkefeld and porcelain filters. It is, therefore, free in the blood and of some considerable size.

Relapsing fever is caused by a spirochaete, and there is considerable difference of opinion as to whether spirochaetes should be classed amongst the bacteria or protozoa.

The infective agent of poliomyelitis is a minute invisible organism, which passes readily through a porcelain filter, so that it escapes the clutches of the systematist altogether.

THE TRANSMISSION OF TYPHUS FEVER BY LICE.

Typhus is a disease associated with poverty and dirtiness. It occurs in temperate climates, and mostly in the winter and spring. In warm climates it is uncommon. In Mexico, where it still flourishes amongst the poor Indians and half-caste population, it is confined to the central plateau 4,000 to 10,000 feet above the level of the sea, and does not affect the population of the lower hot country, although cases are frequently introduced from the higher lands.

Typhus has been shown to be capable of transmission by the agency of body lice (*Pediculus vestimenti*) by Nicolle, Compté, and Conseil (1909), and by Ricketts and Wilder (Wilder, 1911).

THE BIONOMICS OF LICE AND THE MECHANISM BY MEANS OF WHICH THEY MIGHT CARRY INFECTION.

Life-History of the Body Louse.

The life-history of the body louse has recently been studied by Warburton (1909), to whom and to my colleague, Mr. Bacot, I am indebted for most of the following facts on the subject. Unlike fleas, lice have no grub stage. The eggs take one to five weeks or longer to incubate, according to temperature. The young louse when just hatched is a small edition of the parent, and sucks blood at the earliest opportunity. It is, however, not sexually mature; three moults occur, and in about fourteen days its growth is complete and the insect is sexually mature. The females lay 100–200 eggs. Lice, especially when young, are delicate creatures. They are voracious feeders, and must be fed at frequent intervals. They, as a rule, are unable to stand starvation for more than two days. They are very sensitive to heat and drying, and soon succumb at temperatures above 25° C. unless the air be kept nearly saturated with moisture. They live in clothing and bedding, and feed several times

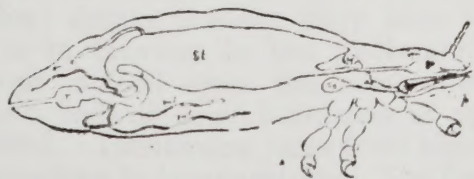


Fig. 18.—Alimentary canal and mouth parts of louse (*Pediculus vestimenti*).

The general arrangement of the alimentary canal may be seen in Fig. 18, which also shows the sac in the floor of the mouth which contains the piercing organ. The four salivary ducts (two only of which are shown) open into the base of this sac. The pharynx is a chitinous organ which collapses by its elasticity, and suction is produced by the contraction of the muscles (*m*) attached to its dorsal surface and the chitinous skeleton of the cranium. The blood is forced into the stomach by the relaxation of these muscles in order from before backwards.

The stomach or crop is a capacious organ with two later diverticuli from its anterior end.

The body louse obtains its nourishment entirely by sucking blood. It is provided with penetrating instruments the apposition of which forms a canal through which the blood is pumped into the stomach by a pharyngeal pump similar to that of the flea. These piercing instruments are not permanently exterior to the head and carried tucked away in a labium as in fleas and bugs, but, as described by Pawlovsky (1906), the apparatus is retractile and contained in a special pocket in the floor of the mouth (Fig. 18, *p*). The anterior part of the mouth is provided with a ring of hooklets, which is everted when the pricker is thrust out (Fig. 19 A, *h*).

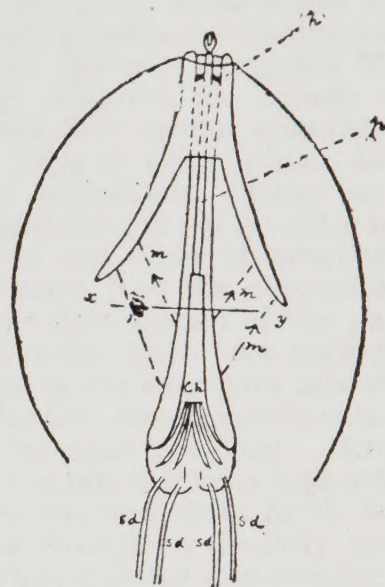


Fig. 19A¹.

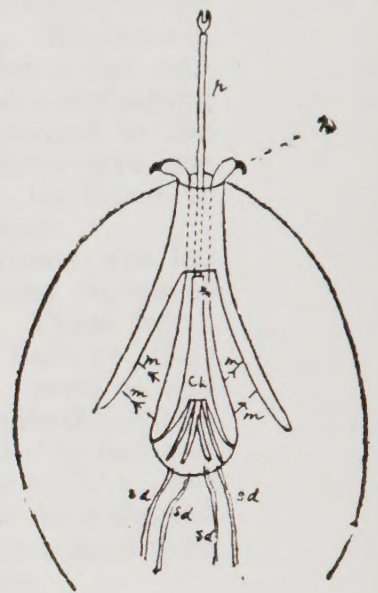


Fig. 19A².

When the insect feeds, the tubular "pricker" (*p*) is protruded through the mouth and penetrates the skin of the host, and the hooklets serve to attach the mouth to the skin. The exact way in which the sucking tube is built up is not quite clear, but from preparations made by my colleagues Mr. Bacot and Dr. Rowland* the arrangement of these parts appears to be as follows.

Three elements enter into the formation of the "pricker," each of which is bifurcated at its base (see Fig. 19 A). From the dorsal and ventral aspects of two of these parts, just anterior to their bifurcation, a chitinous expansion is given off which runs forward and embraces the finer piercing organs (Fig. 19 A and Fig. 19 B, *Ch*). The two together form a sheath round the basal portions of the piercing organs.

The relation of the three elements to one another and how the sucking tube is formed may be seen from Fig. 19 B, which represents a transverse section in the neighbourhood of the line *x-y* in Fig. 19 A¹; *Ch* is the chitinous sheath, *a* the dorsal element which we may call the stylet, *b* the median, and *c* the ventral element. The interlocking of the lateral chitinous expansion of *b* and *c* forms the canal *s.t.* up which blood is sucked.



Fig. 19B.

Fig. 19 A¹, is a diagrammatic representation of the head of a louse with the pricker retracted, A² with the pricker extruded; *p* is the "pricker" made up by the apposition of the three parts mentioned above. Anteriorly these pass through a tunnel in the substantial chitinous piece shaped like an inverted Y, which apparently also forms a skeletal framework for the attachment of the muscles (*m*, Fig. 19 A) which pull the whole organ forward.

Ch is the sheath covering the basal portion of the piercing parts. At the base the bifurcation of the three elements is seen, and also the four salivary ducts (*sd*)

* I am greatly indebted to Mr. Bacot and Dr. Rowland not only for lending me specimens of the mouth parts of the louse, but also for their kindness in making fresh dissections for the purpose of this lecture. The mechanism of the sucking apparatus of the louse is much more difficult to comprehend than that of the flea or bug, and the description given merely represents the conclusions I have been able to arrive at without a prolonged study of the intricate arrangement of the organ.

which enter there, but the precise connexion of which has not yet been made out.

When the whole organ is pulled forwards it not only drives out the "pricker," but evaginates the lining membrane of the sac and everts the ring of hooklets (*h*) whereby the head is anchored to the epidermis.

Summary of the Position with regard to the Transmission of Typhus by Lice.

1. The infection of typhus circulates in the blood during and for some time after the febrile period.
2. It is taken up by lice when they feed upon a patient, and may be transmitted to monkeys by them.
3. As in the case of fleas and plague, a considerable number of insects—ten or more—are required to give a reasonable chance of infection to a monkey, an animal which is probably much less sensitive than man.
4. There is reason to believe that the virus proliferates inside the insect; for, in order to produce infection by means of blood taken from a patient, the volume required is much larger than could possibly be contained in the lice employed (Wilder).
5. The infectivity of lice endures seven days, and seems to be greater some days after feeding on a typhus patient than immediately (Nicolle and Wilder), but the number of experiments so far performed is not adequate to establish this.
6. There is reason to believe that the infection may be transmissible to a second generation of lice (Wilder).
7. The present limitation of outbreaks of typhus to the most vermin-infested section of the population, its occurrence at a period of the year when the clothing is rarely removed from such persons, and washing of either takes place at considerable intervals, and the practical limitation of the disease to cold climates, all receive ready interpretation on the assumption that lice are essentially the porters of infection.
8. Further support is provided by the non-infectivity of typhus under modern hospital conditions, and the success attending prophylaxis directed towards the extermination of insect parasites: and I am unaware of any epidemiological fact inconsistent with the view that lice carry the infection.

THE TRANSMISSION OF AFRICAN RELAPSING FEVER BY THE TICK.

Relapsing fever is widely distributed about the world, and was at one time very common in this country. In 1838 Obermeier discovered the presence of spirochaetes in great abundance in the blood of patients during the febrile attacks. These were subsequently shown to be the cause of the disease.

In 1905 Dutton and Todd (1905), in the Congo, and Koch (1905) in German East Africa, discovered that the tick-fever of Africa was relapsing fever, and that the spirochaete was conveyed from patient to patient by the tick *Ornithodoros moubata*.

Bionomics of Ornithodoros moubata.

These ticks are common in the native caravan routes. The adult feeds several times and lives a long time. They are very hardy insects, and can endure many months without food both in the larval and adult stages. In their habits they more resemble the bed-bug than the majority of the Ixodes; during the day they hide in the earth of the floors or in crevices in the walls and roofs, and at night emerge to feed upon the occupants. The female lays several broods of some hundreds of eggs in crevices of the ground. Incubation lasts from eight days to two months, according to temperature. The first moult occurs within the egg. The young larval *Ornithodoros* somewhat resembles its parent, has four legs but undeveloped sexual organs. It feeds upon blood and moults a few times, after which it is a sexually mature insect.

The number of infected ticks along the caravan routes of German East Africa is considerable. Koch (1905, 1906) found 5 to 15 per cent. contained spirochaetes, and in one instance 50 per cent. of the ticks collected from a particular locality contained spirochaetes.

Ticks, once infected, may retain the infection and transmit it to their progeny, for Dutton and Todd (1905) and Koch (1905-06) found that young ticks raised from the egg were infective. Möllers (1908) further discovered that

the second generation from infected ticks were also capable of giving rise to relapsing fever. The same fact was demonstrated by Hindle (1912) for *Spirochaeta gallinarum* and *Argas persicus*, the fowl tick. These facts, no doubt, account for the large proportion which harbour the infection.

The precise mechanism of transmission in relapsing fever is still uncertain. For a few days after feeding on an infected animal Dutton and Todd (1905) and Koch (1905) found the spirochaetes in the alimentary canal of the tick. Subsequently they disappeared from the stomach and gut, but were found by these observers in some of the internal organs, ovaries, Malpighian tubes, and salivary glands.

Leishman (1909), working in London upon a number of ticks sent from Africa, failed to find spirochaetes, although the ticks were capable of infecting monkeys. He noticed, however, that the cells lining the Malpighian tubes contained large numbers of minute chromatin-containing granules, and that similar granules were present in the ovary, and eggs of ticks, which subsequently gave rise to infective individuals. Ticks in which he failed to find these granules did not give rise to infection.

From these and other observations Leishman was led to the conclusion that the chromatin granules represent a stage in the development of the parasite. These interesting observations have been confirmed by Balfour (1911) in Khartoum in the analogous case of *Argas persicus* and fowl spirochaetes. Some experiments by Hindle (1911) also have a bearing upon this point. Hindle failed to find any spirochaetes in infected ticks kept some time at 21° C., but similar ticks warmed up to 35° C. for a few days showed spirochaetes throughout the body, and all the organs were infective, when injected into suitable animals.

The Structure and Arrangement of the Mouth Parts and Alimentary Canal of Ornithodoros moubata.

The general arrangement of the mouth will be seen from the diagram Fig. 20. The boring instrument or rostrum

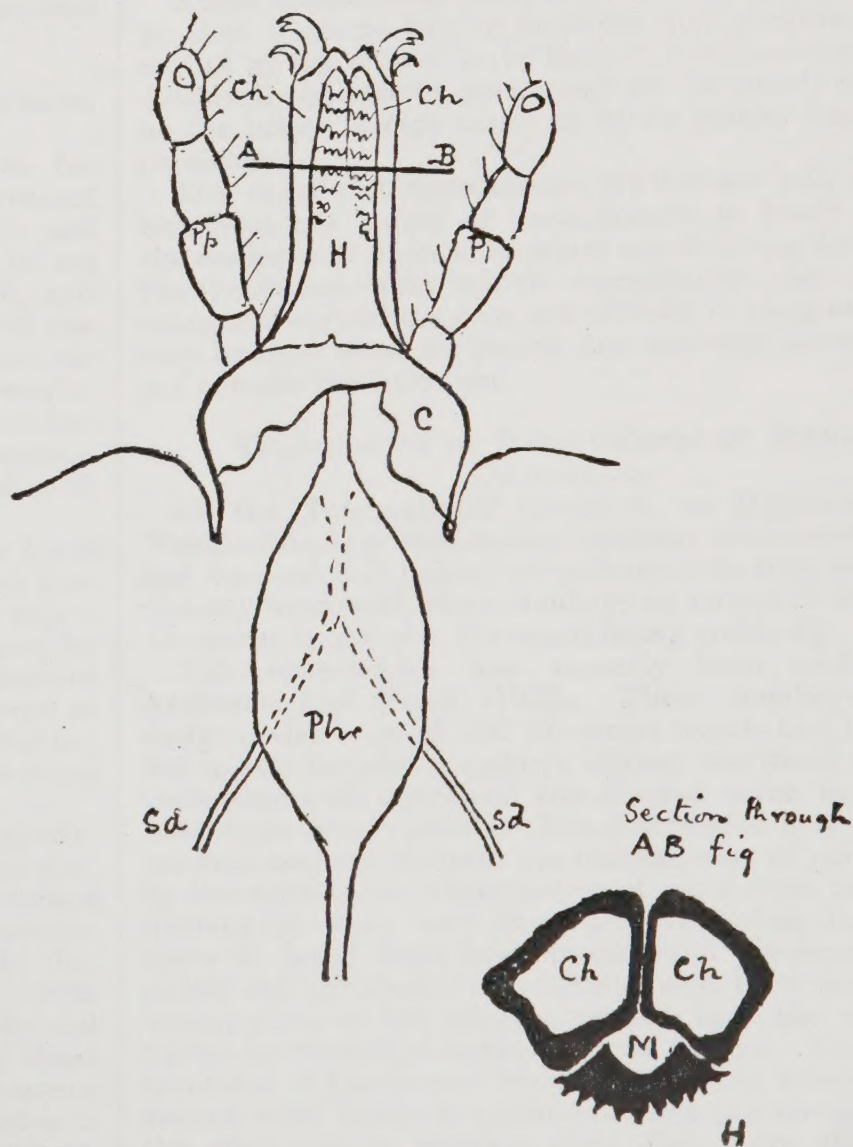


Fig. 20.—Mouth parts of tick (*Ornithodoros moubata*).

consists of three parts, two chelicerae (*ch*) and a ventral hypostome (*h*). The chelicerae are hollow chitinous organs inside which are muscles which operate the terminal claws; the hypostome is barbed. In the act of boring the claws are straightened and the three parts of which the rostrum is

composed are advanced a little further. The claws are again advanced for a further pull, and the barbed hypostome prevents any slipping back. By a succession of these efforts the rostrum is buried in the skin.

The three instruments of the rostrum, when apposed, form a canal, at the base of which is the mouth. This widens into a pharynx, which is alternately compressed and expanded by a co-ordinated contraction of the individual muscle fibres attached to it. The blood is driven by the pump through the narrow oesophagus into the crop or stomach (*st*). The stomach is a capacious pouch (Fig. 21),

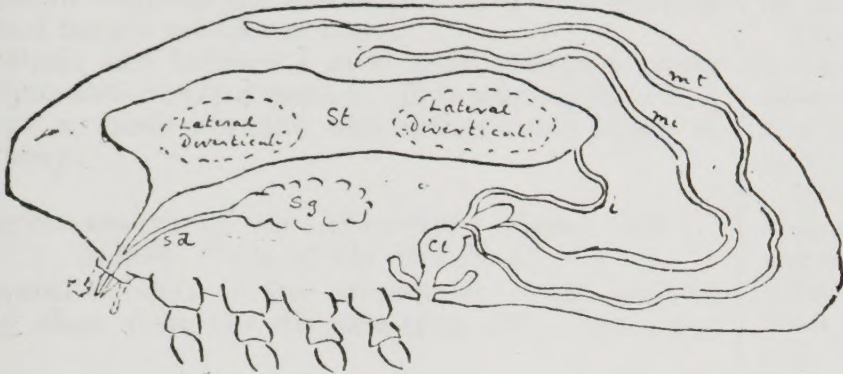


Fig. 21.—Alimentary canal and mouth parts of tick (*Ornithodoros moubata*)

having extensive lateral diverticula, which themselves branch so that after a full meal the organ distends the insect. The intestine is a very narrow tube connecting the stomach to the cloaca (*c*). The anus is not terminal, but opens in the mid-line just behind the last pair of legs.

The salivary glands (*sg*) are of the compound racemose type, each with one duct (*sd*) passing forward to the mouth.

Koch was of opinion that the spirochaetes passed from the salivary glands during the act of sucking, but both Leishman and Hindle consider that the infection is not transmitted by this channel, but that the infective excrement from the Malpighian glands passes out per rectum, and is washed into the puncture made by the insect by means of the coxal secretion which is deposited during the latter stages of feeding.

THE TRANSMISSION OF THE RELAPSING FEVERS OF EUROPE, AMERICA, AND INDIA.

Whether the spirochaetes which are responsible for relapsing fever in various parts of the world represent distinct species (Novy and Knapp, 1906; Uhlenhuth and Haendel, 1907), or merely varieties, does not seem to me proven in view of the observations of Darling (1909), and Manteufel (1908). Anyhow, they are very similar, and can all be transmitted by the tick *Ornithodoros moubata* (Manteufel, 1908, and Neumann, 1909). It is, however, clear that this tick was not the transmitting agent in Ireland and England, where relapsing fever was common fifty years ago, nor is it so in Russia, America, or India, at the present time.

The epidemiology of the disease in these countries is not yet clear. Spirochaetes are such obligatory parasites that the agency of an insect transmitter seems almost necessary. The only certain way of producing the disease is by inoculating a minute quantity of the blood of a patient during the febrile stage. Spirochaetes have been found in the urine, but no one has succeeded in producing infection by this means. It must also be remembered that they can find their way through the unbroken skin.

The distribution of relapsing fever among the population is consistent with the view that insects are necessary, for, like typhus, this disease is in Europe almost confined to the poorest and dirtiest members of the community. It has been frequently suggested that bugs might disseminate the disease. Tietin (1897) and Karlinski (1902) found that the stomach contents of the bed-bug remained infective for two or three days after feeding on the blood of a patient, and Kladnitzky (1908) observed appearances strongly suggestive of multiplication of the spirochaetes in the stomach of the bug. With one exception, however, all the numerous attempts to transmit the disease by the bed-bug have been unsuccessful. Experiments have also been made with fleas by Sargent and Foley (1908) and others. The results were negative. A further reason for doubting the importance of either of these insects is that the disease is not more prevalent at the time of year

these insects abound, but rather the contrary. In Europe the disease occurred in epidemic form throughout the year, the greatest prevalence being usually during winter and spring.

The only remaining ectoparasites are lice—*Pediculus capitis* and *Pediculus vestimenti*. The general bionomics of these insects has been dealt with, and it only remains to point out that their prevalence is not confined to the warmer months, but is greatest during the winter (Hamer, 1910), when clothes are least changed and washed.

Mackie (1907), in an investigation of an outbreak of relapsing fever in a mission school in India, brought forward some rather striking epidemiological facts pointing to lice, rather than bugs, as being concerned with the epidemic. He found spirochaetes in 14 per cent. of the lice taken off the boys. They were present in the alimentary canal, ovary, and Malpighian tubes of these insects. From his observations he came to the conclusion that spirochaetes multiplied greatly in the stomach of the insect, reaching their maximum on the third day. Mackie fed lice from the patients upon monkeys, but he failed to transmit the disease. In two experiments by Sargent and Foley (1910) relapsing fever followed the infection of the clothing by lice from patients.

The spirochaetes of relapsing fever infect rats, and Manteufel (1908) made some observations on the capacity of the rat-louse (*Haematopinus*) to transmit the disease. He first ascertained by forty experiments that, when free from lice, sick and healthy rats could be caged together without the latter contracting the disease, and then repeated the experiments with the addition of lice. Two infected rats were caged together with seven healthy ones. The sick animals were killed by ether at the height of the disease, and then put back into the cage in order that the lice might crawl off the cadavers and attach themselves to the living animals. Three of the seven became infected. In another similar experiment with *Spirochaeta duttoni*, one out of eight rats became infected. Manteufel could not find spirochaetes in the louse outside the alimentary canal, nor in the eggs.

These experiments were confirmed by Neumann (1909), so that it seems highly probable that relapsing fever is spread by lice as well as by the tick *Ornithodoros moubata*. Although the former agent may not be nearly so efficient as the latter, it may make up by its greater numbers and persistency.

The details of transmission by lice are still unknown, but, from the habits of these insects to freely discharge the contents of their alimentary canal during feeding, and the readiness with which spirochaetes can penetrate uninjured epithelium, it is not difficult to imagine how this may happen, even supposing the salivary secretion does not contain the infection.

TRANSMISSION OF POLIOMYELITIS BY STOMOXYS CALCITRANS.

At the International Congress on Hygiene, held in Washington last September, Rosenau announced that he had succeeded in conveying poliomyelitis from an infected monkey to several other monkeys by means of the bites of *Stomoxys calcitrans*, the small biting stable-fly.

This observation has recently been confirmed by Anderson and Frost (1912). Three monkeys exposed daily to the bites of 300 *Stomoxys* which had previously fed on two infected monkeys during the whole course of their illness all developed the disease seven to nine days after their first exposure. The observation is of particular interest because hitherto the transmission of poliomyelitis by the subcutaneous inoculation of blood from an infected monkey has been very uncertain even when large quantities of blood have been transferred. It suggests that either the previous experiments have been made at the wrong stage of the disease, or else that the virus multiplies or intensifies in the body of the fly. The seasonal incidence of the disease being summer and autumn is consistent with insect transmission, but the continuance of the epidemic in Sweden after flies have disappeared indicates that there are other means of spread.

BED-BUGS (*CIMEX LECTULARIUS*) AS PORTERS OF INFECTION.

The general career of the bed-bug is more or less familiar to most people, but it may not be unnecessary to

point out that, unlike fleas, there are no larval or pupal stages, but the insect emerges from the egg as a little bug. For the following facts I am indebted to my colleague, Mr. Bacot, who has made observations on this subject.

The young bug sucks blood on the earliest opportunity, grows and moults, and feeds again. After five moults it is a sexually mature and adult insect. Bugs only visit their hosts for food, and then preferably at night; they strongly resent light, and during the day hide themselves in some cranny of the room or furniture. They are very hardy and do not require the constant feeding which is so troublesome in breeding lice and fleas. They can survive without food for six months or more.

A bug which has imbibed a good meal retires to some secluded spot and slowly digests it. It is some days before he develops a fresh appetite and sallies forth again in search of prey.

The Arrangement of the Alimentary Canal and Mouth Parts of the Bed-Bug.

The general scheme of the alimentary canal will be sufficiently clear from the diagram (Fig. 22). There are

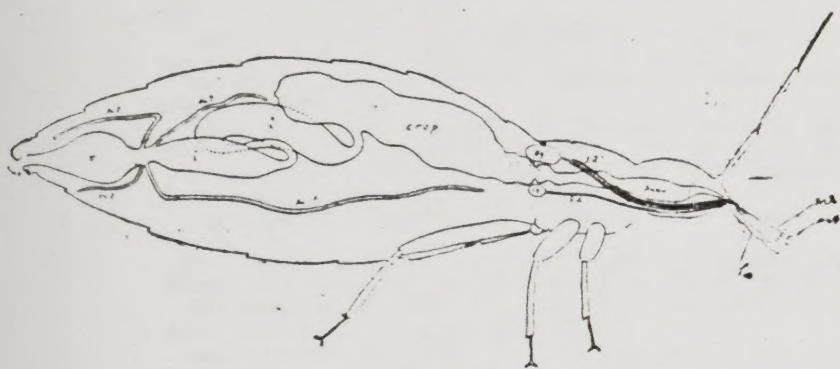


Fig. 22.—Alimentary canal and mouth parts of bug (*Cimex lectularius*).

two pairs of salivary glands (*sg* and *sg*¹) and the duct of the larger of the dorsal pair (*sg*¹) bifurcates shortly after it emerges from the gland and both tubes run forward to the base of the piercing organ. The exact way in which the three salivary ducts on each side terminate has not yet been determined. The mouth parts also differ from those of the flea in that the sucking tube is made up by the apposition of four elements instead of three. These are two maxillae (*mx*) and two mandibles (*mn*). When not in use these delicate piercing instruments are carried in a groove on the dorsal aspect of the three-jointed labium (*la*). Whilst feeding this support is folded backwards under the head.

Experiments on the Transmission of Relapsing Fever, Typhus, and Plague by Means of Bed-Bugs.

The observations of Tietin have already been referred to. Although these show that the spirochaetes of relapsing fever may live from some hours to many days, according to circumstances, in the stomach of the insect, they give no information as to whether the bed-bug can in a natural way transmit the disease.

Christy (1902) and M. Rabinowitch (1907) and Shellack (1909) tried the experiment on themselves without success. Their attempts were very thorough; Shellack, for instance, fed 168 bugs, which had been previously nourished on a diet of rat-blood infected with *Spirochaeta recurrentis*, upon himself. The experiment lasted a month, and was so arranged that a variety of intervals elapsed between the ingestion of infected blood and the second meal.

Breidl, Kinghorn and Todd (1906), and Rabinowitch (1907), and Sergeant and Foley (1910) have also tried to transmit relapsing fever to monkeys by means of bugs. Large numbers of insects were employed by the former observers, sometimes as many as 590 to one monkey.

Their experiments were carried on over two or three months. Bugs which had fed upon an infected monkey at all stages of the disease were used, and the interval between feeding upon the infected and healthy animal varied. Nevertheless, no transmission of the disease occurred.

The only case of a successful transmission was one experiment by Nuttall (1907), who removed a bug shortly after it had commenced to feed upon an infected mouse, and allowed it to complete its meal upon a normal mouse.

Bed-bugs were excluded from consideration as trans-

mitters of typhus by Nicolle (1910) and by Wilder (1911), as the distribution of these insects both in time and space does not coincide with that of typhus. Wilder, however, tried experimentally to convey the disease from monkey to monkey by bugs, but without success.

Verbitski (1904) made a number of experiments on the transmission of plague by the bed-bug. He showed that plague bacilli multiply in the stomach of bugs, as they do in that of fleas, and that their virulence was unimpaired. He succeeded in conveying plague to guinea-pigs by the bites of bugs, but only up to four days after they had fed on an infected animal.

There is really no evidence to incriminate the bed-bug in the case of either typhus or relapsing fever. It is possible to transmit plague experimentally by means of bugs, but there is no epidemiological reason for supposing this takes place to any extent in nature.

There are two differences in the habits of bugs and those of fleas and lice which may possess epidemiological significance. The first concerns their customary intervals between their meals. Bugs show no disposition to feed for a day or two after a full meal, whereas fleas and lice will suck blood several times during the twenty-four hours. The second is in respect to the time the insects retain a meal and the extent to which it is digested before being excreted. Fleas and lice, if constantly fed, freely empty their alimentary canals, and the nature of their faeces indicates that the blood has undergone but little digestion.

Both these insects evacuate such undigested, or half digested, blood per rectum during the act of feeding, and the remnants of the previous meal are thus deposited in the immediate vicinity of a fresh puncture. It is not unlikely that, should the alimentary canal of the insect be infected with plague bacilli, spirochaetes, or the organism responsible for typhus fever, these may be inoculated by rubbing or scratching.

Bugs have not this habit, and in all the cases I have examined their dejections were fully digested, almost free from protein, and consisted mostly of alkaline haematin.

This is, however, probably not the whole explanation, and there is, I believe, much yet to learn as to the mechanisms of insect transmission, and why one blood-sucking parasite is an effective porter and another not, even in the cases of bacterial infection where no stage in the life-cycles of the organism takes place within the insect host.

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As already announced in the JOURNAL, the second International Congress on life-saving and precautions against accidents will be held at Vienna in September (9th to 13th). The Permanent Secretary of the British Section of the Congress is Mr. Samuel Osborn, F.R.C.S., Constitutional Club, Northumberland Avenue, W.C.

THE fourth congress on the hygiene of the dwelling will be held at Antwerp this year from August 31st to September 7th. The following is the programme of subjects proposed for discussion: (1) Hygiene of the emigrant; (2) colonial hygiene; (3) hygiene of ports and ships; (4) the extension of towns. Further information may be obtained on application to the General Secretary, Hotel de Ville, Antwerp.

THE Roborat Company, 23, Cloth Fair, E.C., has recently issued a catalogue relating almost entirely to diagnostic appliances and instruments other than clinical thermometers and stethoscopes. A special feature is the number of means provided for enabling practitioners to make use themselves of methods of diagnosis for the assistance of which they are commonly dependent on the co-operation of laboratory workers.

An Address

ON

MEDICINE AND LIBERTY.

GIVEN AT A MEETING OF THE DEVON AND EXETER MEDICO-CHIRURGICAL SOCIETY ON JANUARY 9TH, 1913.

By WILLIAM GORDON, M.D., F.R.C.P.,

EXETER.

It is, however, certain that men who begin by losing their independence, will end by losing their energy.—Buckle, *History of Civilization in England*, vol. ii, p. 186.

I HAVE to thank this society for allowing me to discuss within its tranquil, scientific atmosphere a question vital to the future of English medicine, needing the calmest and clearest deliberation, yet now forced by circumstance into the arena of political conflict. It is unfortunate that no attempt has hitherto been made, so far as I am aware, to deal philosophically with this question, and in making the attempt I must make large claims upon your indulgence.

The demand has just been made upon English medicine, in the National Insurance Act, to part with a great measure of its independence, and, in considering this demand, there are four questions which we are bound to put to ourselves:

I. What is it that we are asked to part with?

II. To whom are we asked to hand it over?

III. Why has the demand arisen? and

IV. What must be the consequences of our acquiescence?

I. WHAT IS IT WE ARE ASKED TO PART WITH?

It is now the independence of much of our practice, soon of most of it, ultimately perhaps of all of it; and here we have to consider two points.

(a) What is the value of independence to medicine? and

(b) What is the present value to this country of its medical profession?

I propose to show that for the fullest expansion towards perfection of medicine, liberty is essential, and that English medicine at the present time is foremost in the world.

MEDICINE AND LIBERTY IN HISTORY.

If we look back over the history of medicine, as far as it is traceable, we shall have no difficulty in recognizing that there have been four great periods of pre-eminent progress. The first was coincident with the golden age of Greek culture and culminated in the lifetime of Hippocrates, about the second half of the fifth and the beginning of the fourth centuries before Christ. The second occurred rather late in the Renaissance, and its activities centred round Padua in the sixteenth century of our era. The third followed close on the second, reaching from the seventeenth century onwards to culminate in the nineteenth, its activities centering round England. The last, which is but the expansion of the third, began within the nineteenth century, and its activities reach throughout the civilized world.

Now if we examine these periods attentively we shall find that all of them have this salient characteristic in common, a remarkable development of intellectual and personal liberty. The first period corresponds to that wonderful epoch in which human intelligence suddenly attained to heights not since surpassed, and in which admittedly one chief cause of so great a growth was the unexampled intellectual freedom which then permeated the Hellenic world. The second period formed part of that great European revival of learning which followed the flight of Greek scholars to Italy and the invention of printing. As its activities centred around Padua, it was associated with the greatest intellectual freedom of the time, for Venice was then mistress of Padua, and in every way fostered its university, that it might worthily advance the new learning. It was under the protection of the enlightened Venetian Senate that Vesalius enjoyed

